5.0 Repair Surveys

Concern over the repairs program dictated that accurate data be collected to identify the scope of the program. The AAWG conducted two separate surveys of repairs placed on airplanes to collect the necessary data. The first survey occurred in 1992, and the second survey in 1994.

5.1 1992 Fuselage Repair Survey of Stored Airplanes

The surveys were performed on airplanes stored at Mojave, California and Amarillo, Texas and coordinated with airplane owners by the FAA. There were a total of five teams involved in the surveys. Each team was comprised of five engineering representatives from various organizations including FAA Aircraft Certification and Flight Standards Offices, operators and OEMs. Details of this survey can be found in Appendix E of Attachment 2. The prime directive for this survey was to conduct sample surveys of fuselage repairs located below the window belt, Figure 5.1.

The survey teams used the following procedures:

- Survey and document lower surface fuselage repairs on selected Airbus, Boeing, Douglas, and Lockheed airplanes.
- Categorize repairs into three groups using engineering judgment and applicable AAWG screening criteria (Appendix D, Attachment 2):
  - No additional action required (Category A).
  - Repair may require supplemental inspection for damage tolerance or additional rework (Category B and C).
  - Repair does not meet the minimum requirements of a Category C repair (remove and replace repair with Category A, B or C repair prior to return to service).
- Summarize data finding.

A total of 356 repairs were evaluated on 30 airplanes over a three day period.

SCOPE OF REPAIR SURVEYS

- **External visual observation of external lower fuselage plating repairs.**
- **Inspections designed to be conducted quickly, with no more than a work stand and light.**
- **Repairs which clearly do not meet existing Structural Repair Manual guidance will be reported to the operator.**

PURPOSE OF REPAIR SURVEYS

- **Gain first-hand observations of typical repairs.**
- **Sample of numbers, types, proximity, condition of repairs, etc.**
- **Identify SRM quality repairs that may require additional attention to ensure continued airworthiness.**
- **Observe any repairs which are below SRM standards.**
- **Develop a qualitative opinion of the team's concern for repairs as a safety issue, if any.**

DISPOSITION OF SURVEY FINDINGS

- **Document the observations in a standard way that can be combined for all OEMs.**
- **Make recommendations for further effort as appropriate.**

Figure 5.1 Objectives of 1992 Repair Surveys

5.2 1994 Repair Survey of In-service Airplanes

During the 2nd quarter of 1994, the AAWG requested that the OEMs conduct a second survey on airplane repairs to validate the 1992 results and to provide additional information relative to the estimated cost of the assessment program. The OEMs were requested to visit airlines operating their products and to conduct surveys on airplanes in heavy maintenance. An additional 35 airplanes were surveyed in which 695 repairs were evaluated. This survey

was expanded to include all areas of the airframe. The evaluation revealed substantially similar results to the 1992 survey in which 40% of the repairs were classified as adequate and 60% of the repairs required consideration for additional supplemental inspection during service. In addition, only a small number of repairs (less than 10%) were found on other portions of the airframe.

5.3 Survey Conclusions

Figures 5.2 and 5.3 summarize the survey findings. These surveys provided first hand observations of service repairs in terms of type, proximity, condition and number of repairs relative to standardized common criteria. The survey findings were reviewed by the RATG. Figures 5.4 and 5.5 show conclusions and recommendations from the repair surveys. These surveys demonstrated that some repairs of good quality may inhibit damage detection during normal maintenance activities and therefore may need supplemental inspection due to size, configuration and/or proximity considerations.

The repair surveys did not indicate an immediate concern for continued structural airworthiness. The size distribution of repairs, Figure 5.6, indicated a need for assessments to establish inspection requirements for larger repairs and/or smaller repairs in close proximity. It was concluded that operators need updated SRMs and model specific guidance documents to accomplish their repair assessments.

Additionally, the results of the survey did not indicate a sizable number of repairs on structure other than the fuselage. Based partly on this finding, the initial task is limited to the external fuselage pressure boundary [fuselage skins and bulkhead webs] Future rule making activity would address the remaining primary structure. This limitation is based on two considerations.

First, the fuselage is more sensitive to structural fatigue than other airplane structure because its normal operating loads are closer to its limit design loads. Stresses in a fuselage are primarily governed by pressure relief valve settings of the environmental control system, and these are less variable from flight to flight than the gust or maneuver loads that typically determine the design stresses in other structure. Second, the fuselage is more prone to damage from ground service equipment than other structure and requires repair more often. The results of the second survey described above supports the conclusion that repairs to the fuselage are far more frequent than to any other structure.

AIRPLANE MODEL	AIRPLANES SURVEYED ('92/'94/TOTAL)	REPAIR CLASSIFICATION		
		REPAIRS REQUIRING NO ADDITIONAL ACTION (CATEGORY A) ('92/'94/TOTAL)	REPAIRS REQUIRING SUPPLEMENTAL INSPECTIONS (CATEGORY B OR C) ('92/'94/TOTAL)	TOTAL REPAIRS SURVEYED ('92/'94/TOTAL)
727	6 / 7 / 13	39 / 100 / 139	66 / 109 / 175	105 / 209 / 314
737	5 / 4 / 9	41 / 17 / 58	49 / 66 / 115	90 / 83 / 173
747	2 / 5 / 7	13 / 37 / 50	32 / 130 / 162	45 / 167 / 212
DC-8	0 / 3 / 0	0 / 56 / 56	0 / 43 / 43	0 / 99 / 99
DC-9	6 / 4 / 10	21 / 37 / 58	32 / 16 / 48	53 / 53 / 106
DC-10	0 / 4 / 4	0 / 12 / 12	0 / 21 / 21	0 / 33 / 33
A-300	9 / 0 / 9	17 / 0 / 17	18 / 0 / 18	35 / 0 /35
L-1011	2 / 0 / 2	12 / 0 / 12	16 / 0 / 16	28 / 0 / 28
F-28	0 / 8 / 8	0 / 10 / 10	0 / 41 / 41	0 / 51 / 51
TOTAL	30 / 35 /65	143 / 269 / 412	213 / 426 / 639	356 / 695 / 1051

Figure 5.2 AAWG Fuselage Surveys Statistics

- BASED ON AAWG REPAIR CRITERIA WITH OEM SIZE AND PROXIMITY LIMITS
- INSPECTED 65 AIRPLANES
  - 13:727, 9:737, 7:747, 3:DC-8, 10:DC-9, 4:DC-10, 9:A300, 2:L-1011 8:F-28's
- RESULTS
  - 1051 REPAIRS ASSESSED - 40% CLASS A, 60% CLASS B/C
  - AVERAGE OF 16 REPAIRS PER AIRPLANE
- GENERALLY THE REPAIRS WERE OF GOOD QUALITY AND APPEARED TO BE PER SRM
- THE SIZE/PROXIMITY CRITERIA DETERMINED ALMOST ALL CLASS B/C REPAIRS

Figure 5.3 Summary of Survey Results

- SURVEYS CONFIRM THE NEED FOR REPAIR ASSESSMENT EVALUATIONS
- NO IMMEDIATE REPAIR SAFETY CONCERN WAS OBSERVED
- OPERATORS NEED REPAIR ASSESSMENT PROCEDURES FROM OEMs FOR EXISTING AND NEW REPAIRS
- OLDER AIRPLANES GENERALLY HAVE MORE REPAIRS
- REPAIR ASSESSMENT TRAINING IS ESSENTIAL FOR:
  - OPERATORS
  - FAA PMIs OR FOREIGN EQUIVALENT
- THE VAST MAJORITY OF REPAIRS ARE ON THE FUSELAGE PRESSURE SHELL

Figure 5.4 Repair Survey Conclusions

- OEMs SHOULD UPDATE THE STRUCTURAL REPAIR MANUALS AND DEVELOP GUIDANCE MATERIAL FOR NEW AND EXISTING REPAIRS
- TYPICAL IMPLEMENTATION TIME FOR ANY SUPPLEMENTAL INSPECTIONS OF REPAIRS SHOULD BE AT DESIGN SERVICE GOAL OR NEXT ACCESS OPPORTUNITY WHICH EVER IS LATER
- THE RULE SHOULD BE LIMITED TO REPAIRS ON THE FUSELAGE PRESSURE BOUNDARY

Figure 5.5 AAWG Recommendations From Survey Results

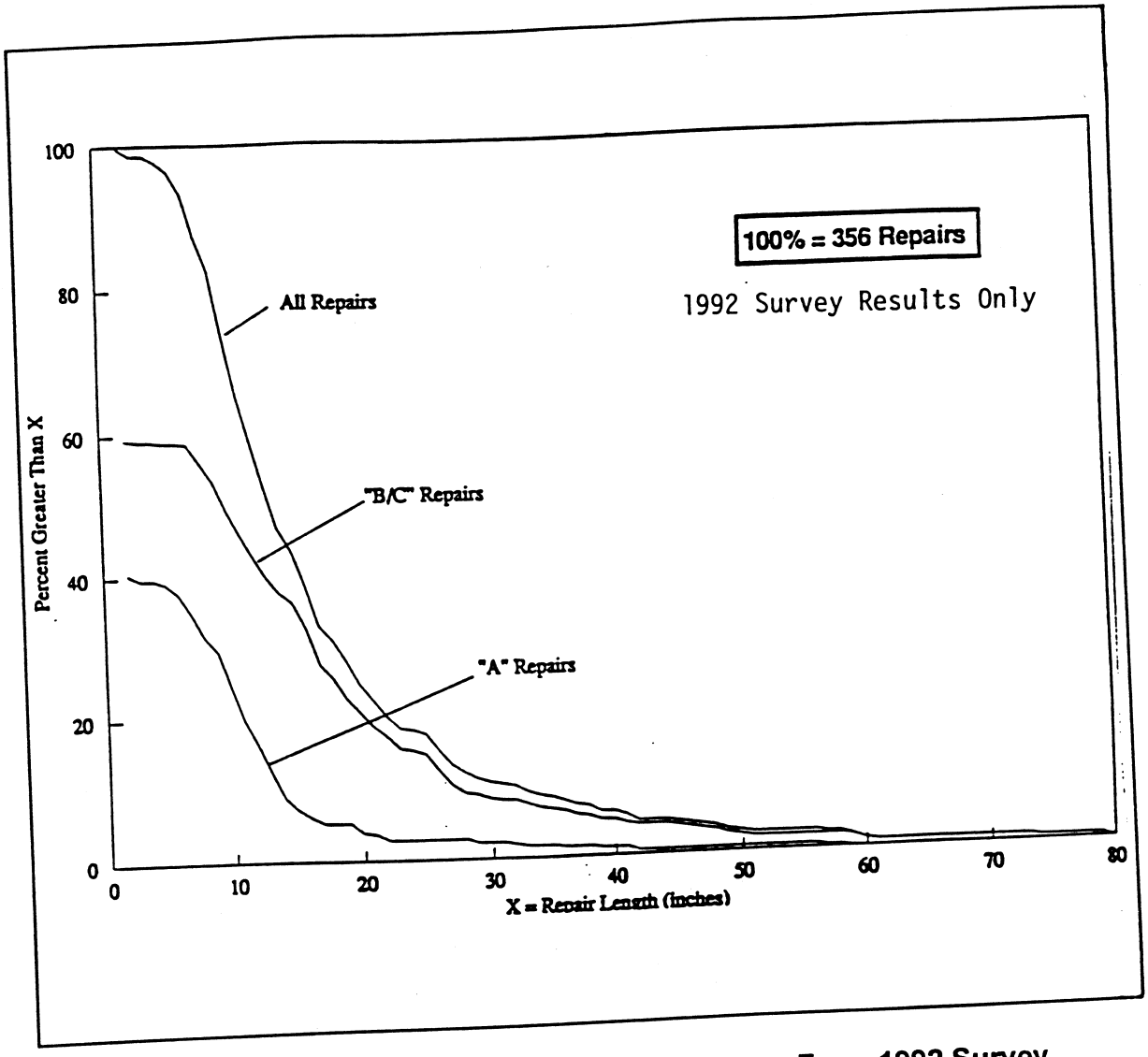

Figure 5.6 Fuselage Repair Size Distributions From 1992 Survey

5.4 Repair Assessment Cost Estimate

The AAWG also requested that the OEM examine the cost issues that might be incurred as a result of implementing the repair assessment guidelines. Data from both the 1992 and 1994 surveys were used to baseline assessment and inspection costs. The following ground rules were agreed to by the OEMs in developing the data:

- For the purposes of the estimate, the cost would be for one airplane of each type for a ten year period.
- The 1992 and 1994 data would be used to establish the number of repairs existent on a particular type at the assessment implementation time.

- The number of repairs determined in step two would be arbitrarily increased by 15% to account for repairs on the wing and empenange. This assumption is in fact very conservative based on the actual number of repairs found on the wing and empennage during the 1994 survey.
- The number of repairs requiring supplemental maintenance would be 60% of the total repairs on a given airplane at the implementation time.
- An individual repair would require the following time estimates for each maintenance operation:
  - One hour for repair classification.
  - Two hours for each repair inspection.
- Repairs requiring inspection were assumed to be inspected at the following times:
  - Each repair requiring inspection is inspected at the time of assessment.
  - One-half of the repairs are re-inspected at every 'C' check interval.
  - One-half of the repairs are re-inspected at every '4C' check intervals.
- The cost estimate does not include:
  - Any record search that an operator may need to do to determine when a particular repair was installed.
  - Any cost of administration incurred by an operator in executing this program:
    - ◊ Updating maintenance programs and obtaining FAA approval.
    - ◊ Any record keeping as defined in the operator's approach to program implementation.

Figure 5.7 shows the projected total number of repairs on an airplane by airplane type at the model specific assessment implementation time (see Figure 6.2). Figure 5.8 shows the estimate of the number of man-hours required per aircraft over the next ten years of operation. The total cost for assessment, excluding administrative costs, range from 80 man-hours to 350 man-hours per airplane.

MODEL	PROJECTED No. OF FUSELAGE SKIN REPAIRS (AT ASSESSMENT IMPLEMENTATION TIME)	No. OF "OTHER" REPAIRS (AT ASSESSMENT IMPLEMENTATION TIME) [1]	TOTAL REPAIRS (AT ASSESSMENT IMPLEMENTATION TIME)
727	29	5	34
737	34	6	40
747	37	7	44
DC-8	38	7	45
DC-9	18	3	21
DC-10	16	3	19
A300	33	4	37
L-1011	TBD [2]	TBD [2]	TBD [2]
F-28	10	2	12

[1] Very few external repairs were found on the wing and empennage. The analysis employs the AAWG estimates contained in the January 1994 meeting minutes (85% of the repairs are on the pressure shell and 15% are on other primary structure.

[2] Similar results are expected.

Figure 5.7 Estimate of Total Number of Repairs At Model Specific Assessment Implementation times

MODEL	PROJECTED No. OF REPAIRS PER A/C (AT ASSESSMENT IMPLEMENTATION TIME)	ESTIMATED No. OF REPAIRS WHICH MAY REQUIRE SUPPLEMENTAL INSPECTION (AT ASSESSMENT IMPLEMENTATION TIME)	ESTIMATED MAN-HOURS PER A/C OVER NEXT 10 YEARS [1]
727	34	19	210 HOURS
737	40	26	270 HOURS
747	44	34	350 HOURS
DC-8	45	19	220 HOURS
DC-9	21	9	110 HOURS
DC-10	19	12	120 HOURS
A300	37	31	215 HOURS
L-1011	TBD [2]	TBD [2]	TBD [2]
F-28	12	10	80 HOURS

[1] Cost figures based on 1.0 Hr. per repair assessment and 2.0 Hr. per repair inspection. Assumed 1/2 of the repairs inspected at "C" checks and the other 1/2 at four times the "C" check interval.

[2] Similar results are expected.

Figure 5.8 Cost of Repair Assessment and Supplemental Inspections